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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

PLASTICS PROCESSING

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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PLASTICS PROCESSING

EIGHTY-FIVE years ago plastics were virtually unknown. Today they constitute one of our major industries and principal fields of industrial activity. The use and application of plastics have become so broad and extensive that from the time we arise in the morning until we retire in the evening, we are in almost constant contact with articles made wholly or partially from plastic, or on which plastics are used for decorative purposes.

The statement that "Necessity is the mother of invention" probably has never applied to anything so appropriately as to the rapid development of the plastics industry. During World War II the shortage of essential materials required the adaptation of suitable substitutes, and plastics were called on to fill the bill in countless applications. The record of the major role played by these materials in the military effort is a fitting testimony to the success of their applications. Shells, rockets, radar equipment, medical kits, and aircraft canopies and propellors represent a partial list of items where plastics were used. In many instances the substitute proved superior to the material replaced and has been permanently adopted.

Although plastics are still used generously for military applications, it is the civilian and industrial products that provide outlets for most of the plastics produced in the country. They are employed in thousands upon thousands of consumers goods, and in many cases the application may be unrecognized. One is hard put to name an industry that does not use or rely on plastics in one way or another. Automotive, aircraft, communications, electrical goods, sporting goods, furniture, hardware, and toys and novelties are a few of the industries which consume plastics in large quantities. Plastics can no longer be regarded as substitutes. They now take their place along side of wood, metal, stone and ceramics as basic engineering materials. The 2,600,000,000 pounds of plastics produced in 1952 represented a 500 per cent increase over 1942 production and reflects the great strides that are being made in the industry.

WHAT ARE PLASTICS?

Plastics seem to defy a simple, yet all inclusive definition, as evidenced by the variety of wordy efforts that appear in the literature. For the present purpose, however, it will suffice to identify them as organic materials which through the application of heat and pressure, either singly or in combination, can be converted into solids having definite shapes and forms. All utilization of plastics, however, does not involve such processing. There are many applications such as in lacquers and coatings where these same materials are not transformed into rigid articles.

There are many materials from which plastics are made, each of which can be classified as one of the following: synthetic resin, natural resin, cellulose derivative or protein derivative. By the proper choice of the basic ingredient, a finished plastic article can be made to have practically any given set of physical, chemical or electrical properties desired. Add to this the fact that all plastic products are light weight, relatively cheap, and adaptable to

mass production techniques, and the big trend toward their utilization is readily understood.

All of the basic plastic materials, regardless of their source, are further classified as being either *thermoplastic* or *thermosetting*.

The *thermoplastics* are those materials which undergo only a physical change during processing. Plastic products made from these materials might be considered analagous to ice. They will liquify under the application of heat and pressure but upon cooling will re-solidify. In this respect they might be regarded as being reversible. Included in this group are the cellulose derivatives, casein, polythene, fluorocarbons, polystyrene, acrylics, nylon and the vinyls.

The *thermosetting* materials, on the other hand, become rigid through the medium of a chemical reaction that occurs under the influence of heat and pressure. Once they have been formed into a product, they cannot be softened by heat and reformed. Consequently these materials are classified as irreversible. The ureas, polyesters, cold molded, alkyds, melamines, and the phenolics are typical examples.

Development of Plastics

The first commercial plastic in the United States was developed by John Wesley Hyatt in 1868 and resulted from his search for a substitute for ivory. The basic ingredient was cellulose nitrate and the plastic subsequently acquired the familiar name, celluloid. Among the early well known applications of this product were billiard balls, denture plates, collars and cuffs, shirt fronts and window curtains for cars. Its flammability has greatly rerestricted the use of this plastic. However, it is still employed for printed cards, buttons, toilet articles and spectacle frames.

The next noteworthy advance came in 1895 with the introduction of shellac as a plastic. Shellac is a natural resin obtained from the lac bug of India and South Asia, and was used initially in the manufacture of phonograph records. This is still one of its major applications, although shellac is used widely as a protective coating and as an insulating material in the electrical field.

The year 1909 is one of the most important in the sequence of developments because it marks the advent of the first synthetic plastic. The honor for this achievement goes to Dr. Leo H. Baekeland who produced the phenol-formaldehyde resin used as the basic ingredient. The phenolic plastics have numerous outstanding properties and are widely used by the communications, automotive and aircraft industries. They are used more extensively than any other group of plastics.

Another milestone also occurred in 1909 with the appearance of cold molded plastics, so called because originally they were molded without any heat. Plastics of this nature are classified as being either organic and non-refractory or inorganic and refractory. The organic types consist of binders of pitch, asphalt or a synthetic resin with fillers of asbestos or diatomaceous earth. The inorganic group usually contains clay as a binder with asbestos or cement as fillers. These materials are currently used for electrical switch parts, cooking utensil handles and battery boxes.

The next recorded development took place in 1919 when plastics were made from casein, a protein product obtained from sour milk. This is of importance only because it represented the first plastic to be derived from protein. The poor moisture resistance of the casein plastics has limited their usefulness very materially.

It is of interest to note that up until 1926 there were only five different types of plastics available commercially, and of those five, four were based on materials found in nature. However, since that date new materials have been developed at an amazing rate, most of which are entirely synthetic.

The Plastics Industry

The plastics industry can be segregated conveniently into three separate categories, namely manufacturing of materials, processing, and finishing. Although there is a certain amount of overlapping, generally most of the companies in the plastics field will be engaged in only one of these categories.

Materials manufacturing includes those companies who prepare the resins or other ingredients that go into the production of the various types of plastics. Their products are passed on to the processors in the form of powders or pellets.

The processing phase of the industry involves the conversion of the plastic powders or pellets into some sort of solid shape or form. Companies in this category are concerned with molding the plastics to produce a desired shape; extruding the material to form films, rods, tubes, filaments and the like; calendering to form sheets and film or to coat paper and fabrics; and laminating plastic impregnated paper, cloth and wood in the form of sheets, rods and tubes.

The finisher or the fabricator takes the processed plastics and where necessary converts them into the finished, saleable products. All types of machine tools commonly used in metal working can be employed.

The following discussion will be concerned with the processing phase of the industry and will describe in more detail some of the methods and equipment used.

SOME MAJOR PLASTIC MATERIALS

Date	*Material*	*Type**	*Examples of Applications*
1868	Cellulose Nitrate	TP	Eye glass frames, heel covers, fabric coating.
1909	Phenol-Formaldehyde	TS	Telephone hand sets, TV cabinets, radio tube bases.
1909	Cold Molded	TS	Knobs and handles, switch bases and plugs, small gears.
1919	Casein	TP	Knitting needles, buttons, buckles, toys, novelties, adhesives.
1926	Alkyds	TS	Electrical bases, light switches, television tuning devices.
1927	Cellulose Acetate	TP	Tooth brushes, toys, lamp shades, combs.
1929	Urea-Formaldehyde	TS	Lighting fixtures, radio cabinets, scale housings.
1931	Acrylic	TP	Brush backs, costume jewelry, signs and displays, reflectors.
1932	Cellulose Acetate Butyrate	TP	Pipe and tubing, portable radio cases, tool handles.
1935	Ethyl Cellulose	TP	Flashlight cases, edge moldings on cabinets, car hardware.
1936	Polyvinyl Chloride	TP	Toys, wire and cable insulation, work gloves, raincoats.
1936	Polyvinyl Acetate	TP	Flash bulb lining, heat sealing film.
1938	Polystyrene	TP	Kitchen housewares, wall tile, instrument panels, toys.
1938	Nylon (Polyamides)	TP	Gears, tumblers, faucet washers, brush bristles, fishing lines.
1938	Polyvinyl Acetals	TP	Safety glass interlayer.
1939	Melamine-Formaldehyde	TS	Tableware, buttons, distributor heads, table tops.
1939	Polyvinylidene Chloride (Saran)	TP	Pipe and tubing, upholstery fabric and screening.
1942	Polythene	TP	Flexible ice cube trays, squeezable bottles, bags, rain capes.
1942	Polyesters	TS	Automobile bodies, interior partitions, luggage, skylights.
1943	Polyfluoroethylene	TP	Valve seats, pump diaphragms, gaskets, laboratory tubing.

* TP — Thermoplastic.
TS — Thermosetting.

Courtesy of the Society of Plastics Industry, Inc.

MOLDING OF PLASTICS

Numerous techniques can be employed in the molding of plastics, including compression, transfer, injection, blow, pulp and solvent molding methods. The first three of these are the most widely used and will be considered here.

Molding Compounds

Although the finished plastic is identified as to type in accordance with the nature of the basic ingredient employed, there are usually several other components that may be included in the material charged to a mold.

The basic ingredient is also called the binder because, in addition to imparting certain characteristic properties to the molded product, it also serves to bind the other materials and hold them together.

Frequently a filler is used to supplement or modify the physical properties of the end product, and there are countless materials that can be employed for this purpose. Wood flour is commonly used to add body, asbestos for heat resistance, and macerated rags for high impact resistance. Fillers of this nature are most usually incorporated in thermosetting plastics to be compression molded.

As mentioned previously, the thermosetting plastic materials achieve their rigidity through a chemical reaction that takes place in the mold under the influence of heat and pressure. It is sometimes desirable to speed up or retard the reaction and to accomplish this, a catalyst which will act either as an accelerator or inhibitor is added, in accordance with the need.

Suitable dyes are included to give the product the desired color. The nature of the basic ingredient will usually determine whether or not a dye can be used. In some instances the dye and the binder will undergo a reaction which produces an unfavorable effect. For example, phenolic plastics are not usually found in pastel shades because the phenol has a destructive action on most light color dyestuffs.

It is often found that the plastic product will stick to the mold and can be removed only with difficulty or with damage. To prevent this undesirable occurance, a lubricant may be incorporated in the mixture to be molded. Wax is usually employed for this purpose, although care must be observed in its application as a scum will be left on the surface of the molded article if too much lubricant is used.

Finally it is necessary that the molding compound have good flow characteristics so that it can move easily and fill all of the space in the mold cavity quickly. This feature is obtained through the media of materials called plasticizers.

Thus, a plastic compound ready for molding may contain any combination of these six ingredients. Those to be used and the relative quantities employed will depend mainly on the nature of the basic material, the type of molding and the application of the molded product.

Molds

Before launching into a discussion of the individual molding processes, it might be well to consider briefly the molds themselves, since they play a most important role. It is within the confines of a mold that the apparent magical change occurs

whereby a shapeless powder or pellet is transformed into countless bright shiny plastic products.

Molds are very expensive to fabricate because they must meet so many exacting requirements. The plastic product will be an exact duplicate of the mold in every detail, even to the finish, and consequently the mold must be dimensionally accurate and mechanically perfect. It must be made of materials which will withstand the high temperatures and pressures to which it will be subjected and to resist the very abrasive action of the plastic powders. It must be of rugged construction to bear up under the unusually large stresses that are encountered. In order to meet these demands, the molds are usually constructed from tough, high quality alloy steel and are frequently chrome-plated to give greater protection against rust, corrosion and wear.

The mold cavities may be made either by machining a solid metal block or by hobbing, which involves forcing a hardened steel master of the product into a softer steel block. The latter is by far the cheaper of the two, since a hob can be machined much more easily than can a cavity.

A mold is always divided into two parts, one of which has the outside shape of the article to be made and the other has the inside shape. The top part of the mold is usually referred to as the plunger or the top force, and the bottom part is called the cavity or bottom force. A mold may contain any number of cavities, but for each cavity there must be a corresponding top force.

For simple plastic articles, the cavity section of the mold can be all one piece. However, for articles with under-cuts, cores or inclusions, a two part or split-cavity mold is required.

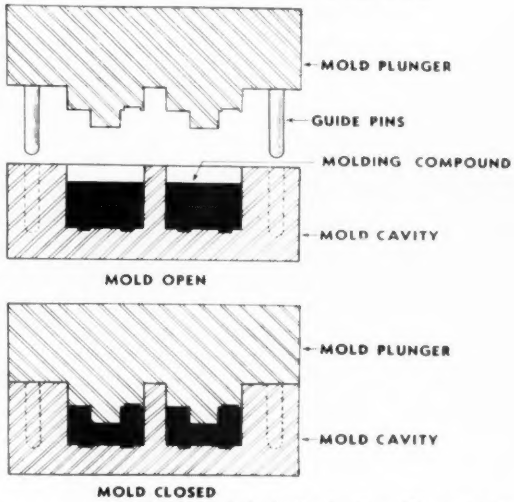
Molds can be classified as either automatic, semi-automatic or hand molds. An automatic mold is permanently attached to the press and both charging of the molding compound and removal of the molded product are accomplished automatically. A semi-automatic mold is also permanently fixed to the press, but the loading and removal operations are accomplished by hand. A hand mold is one which is removed entirely from the press to extract the finished product. Most of the molds are of the semi-automatic type.

Molds can be classified further as being flash, positive or semi-positive, depending upon the manner in which they close. A flash mold is so constructed that as it closes some of the plasticized compound is squeezed out of the mold. When the product is extracted it has a ring of flash around the top rim which must be removed. Molds of this type are cheap to make, but plastic compound is wasted since the amount charged to the mold must be in excess of that required for the product. These molds are commonly employed to produce thin, flat articles.

A positive mold, on the other hand, does not provide for any escape of the plastic material. The full molding pressure is continually exerted on the compound. Such molds are usually employed for bulky materials which require considerable compression, and the charge to the mold must be very accurately measured.

The semi-positive mold is a combination of the other two and is the one which is used most extensively. These molds operate as a flash mold for most of the closing stroke and as a positive mold at the end of the stroke.

COMPRESSION MOLDING

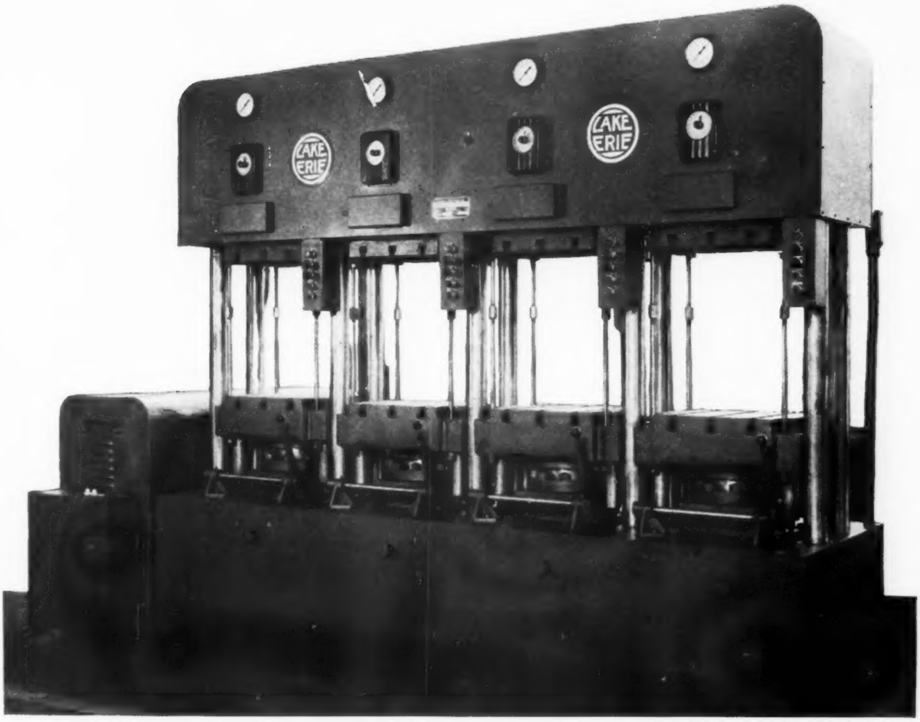


Courtesy of the Hydraulic Press Mfg. Company

Figure 1

Compression molding is widely used for the thermosetting materials and very infrequently for the thermoplastics. The principle involved is relatively simple. The plastic compound is loaded in the cavity of a heated mold, after which the mold is closed and subjected to high pressure. The molding compound becomes fluid and fills the confines of the mold, and continued application of heat and pressure promote the chemical reaction that permanently hardens the plastic in the shape of the mold.

Although the principle of compression molding may be simple, the execution frequently is not. There are a number of critical factors which, if not carefully controlled, can ruin the molded product. Extreme care must be observed to assure that the accurate amount of material is loaded in the mold. To prevent errors and to facilitate the loading operation, the molding compound is frequently preformed into pills or pellets. Where the compound is loaded in powder form, loading trays are available for use on multi-cavity molds. It is also generally desirable to preheat the molding compound. This not only removes any traces of moisture or



Courtesy of Lake Erie Engineering Corp.

Figure 2 — 50 ton 4 in 1 Compression Molding Press.

volatile materials, but also reduces the time required for the overall molding operation.

Each plastic resin or binder has an optimum molding temperature and pressure which must be very closely observed. If the temperature is too high, the material may harden before it has completely filled the mold; if too low, the time required to attain rigidity will be so excessive as to adversely affect the economics of the process.

The length of time the plastic must remain in the closed mold is known as the *cure* and is governed not only by the nature of the plastic but also by the thickness of the molded article. During the *cure* it is essential that the temperature and pressure be maintained at constant levels. Incomplete curing will cause the article to be flexible.

Frequently gas is formed by the chemical reaction and, if not permitted to escape, will result in blisters on the molded product. This is prevented by allowing the mold to breathe, which consists of quickly opening and closing the mold at some critical, predetermined period.

If the flow of the molding compound is irregular and uneven, the molded product may be warped. If contaminants are present in the molding compound, the surface of the finished article may be pitted. A dull finish will result if the mold does not have a good surface finish, and an orange peel appearance may be obtained if the particles of molding compound are too coarse.

These are a few of the precautions that must be observed and some of the unfavorable results that occur if they are not followed.

Presses for Compression Molding

Any type of a press that will open and close easily and maintain a high pressure can be used for compression molding. Consequently there are many types of presses currently employed for this purpose. Most of them are operated hydraulically, although toggle presses, which are motivated by an electric motor through a series of gears and cam and toggle action, are also used.

Hydraulic presses are further classified as self-contained or system presses, depending upon whether the press has its own hydraulic system or must rely on a central accumulator system to supply pressure to a battery of presses.

Some of the types of hydraulic presses commonly used are described briefly below.

Hand Operated Press

This is the simplest of all presses and is used mainly for those operations where the mold is removed from the press for disassembly. It consists essentially of a hydraulic ram mounted on the base

of the frame, a bottom platform located on top of the hydraulic ram, and a top platform or head located some distance above the bottom platform. The distance between the two platforms is known as the daylight opening and is adjustable. Heating platens are affixed to each platform and the two halves of the mold are mounted on these platens. Heating may be provided by either electricity, steam or superheated water. In the operation of the press, the top platform remains stationary while the hydraulic ram moves the bottom platform up to close the mold and create the desired pressure. Hand presses usually have capacities up to 50 tons.

Up-Ram, Semi-Automatic Press

Most of the presses are of the semi-automatic type wherein the operator loads the mold, pulls a lever to move the ram and close the mold and pulls the same lever to retract the ram and open the mold. The two parts of the mold are permanently attached to the press, but the molded part may be removed either by hand or automatically. The molds are usually cored or channeled so that the heating medium can be applied directly.

The operation of this press is similar to that of the hand operated press. The top part of the mold remains fixed while pressure is applied by the hydraulic ram to the bottom part, or mold cavity. However, the semi-automatic press usually provides for two operating pressures, a low pressure to be used in closing the mold and a high pressure to be applied after the mold has closed. The capacity of this type of press will usually range from 50 to 3000 tons.

Side-Ram or Angle Press

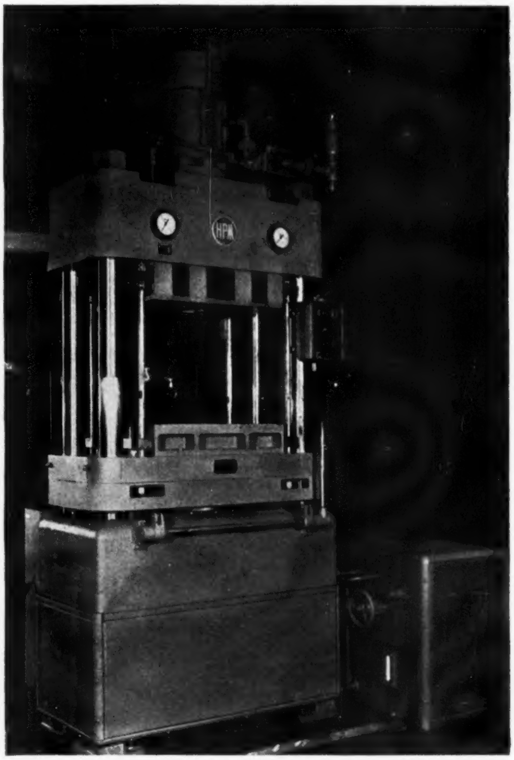
This variety of semi-automatic press is employed for split cavity molds and will have a horizontal as well as a vertical hydraulic ram. The horizontal or side ram holds the split cavity together and is closed when the mold is charged with compound. The vertical ram forces the top section of the mold down, remains there until the product is cured, then rises. The side ram moves out to split the cavity and permit the product to be withdrawn.

Tilting Head Presses

This is similar to the regular up-ram press except that the head containing the top part of the mold can be tilted back at a 90 degree angle. This makes the loading zone more accessible and is very convenient for charging multi-cavity molds.

Fully Automatic Press

There are some fully automatic presses which are operated by mechanical, electrical and electronic devices and which perform all operations automatically including loading of the mold. The powdered molding compound is contained in a hopper and a feeding device regulates the amount that is charged to the mold.



Courtesy of the Hydraulic Press Mfg. Company

Figure 3 — 250 ton Transfer Molding Press.

Lubrication Requirements for Compression Presses

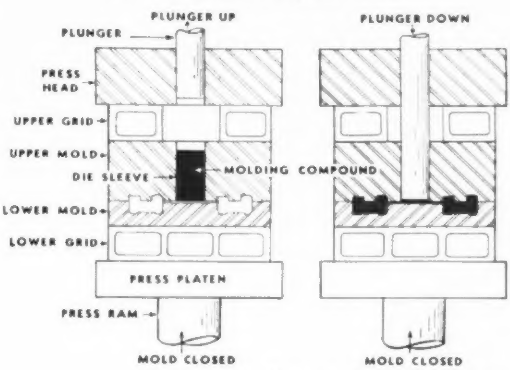
The hydraulic system is the heart of the press, and satisfactory performance is most essential for successful press operation. Hydraulic systems contain precision parts and their continued smooth performance depends upon proper attention. Experience has shown that hydraulic systems, if treated with a reasonable amount of care, will seldom cause trouble. However, when trouble does occur, maintenance costs can be high and the downtime expensive.

Proper care begins with the proper choice of the hydraulic medium. It is generally true that too little attention is given to the selection of the fluid to be used in the hydraulic system. The results of a recent survey indicate that 70 per cent of the troubles that occur in a hydraulic system are due to improper condition of the hydraulic oil. This certainly emphasizes the importance of using the proper fluid. First of all the oil must have certain physical properties which will enable it to perform its task most efficiently, and in this regard the

pump manufacturers' recommendations should be closely followed. Viscosity is perhaps the most important single property that will relate to performance efficiency, and oils having SSU* viscosities ranging from 150 to 700 seconds at 100°F. are usually employed, depending upon the operating conditions. Of particular importance to operators of hydraulic presses is the length of time the hydraulic oil will remain in service and continue to give trouble free operation. Downtime means lost production, and lost production is costly. The petroleum industry has developed premium grade hydraulic oils, so designed as to have long service life, keep the hydraulic systems clean, and reduce downtime to a minimum. These oils will resist oxidation, prevent rust formation and foaming, and will separate water quickly. It has been adequately proved that the use of premium grade hydraulic oils will result in drastic reductions in maintenance costs.

A No. 2 NLGI sodium-calcium base grease should be used for pump bearings and for grease lubricated motor bearings. For motor bearings requiring oil lubrication, a high grade straight mineral oil having an SSU viscosity at 100°F. of 250-350 seconds is recommended.

TRANSFER MOLDING



Courtesy of the Hydraulic Press Mfg. Company

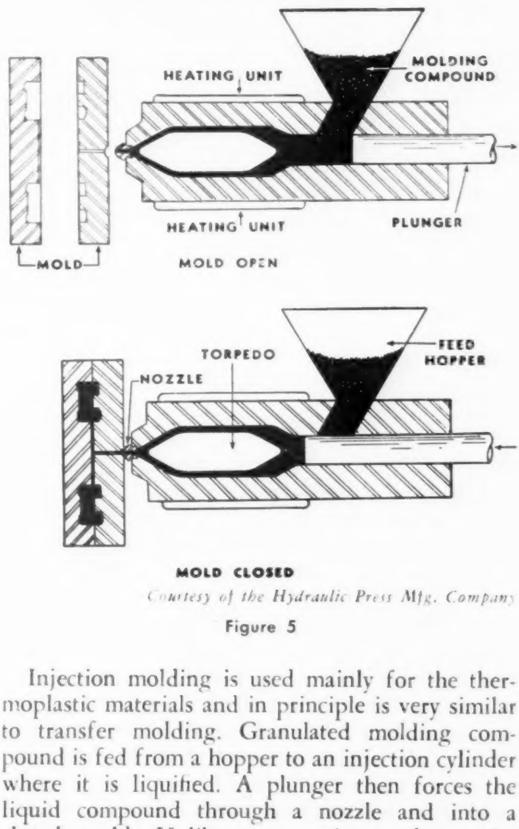
Figure 4

Transfer molding is also used almost exclusively for thermosetting plastic materials and can be considered as a variation of compression molding. In fact, a conventional compression press can be readily modified to accommodate transfer molding. The big difference between compression and transfer molding is in the manner in which the mold is loaded. In compression molding, solid molding compound in the form of powder or pellets is charged to the open cavity of the mold, after which the mold is closed and the compound is plasticized and cured. In transfer molding, the compound is converted to a molten or plasticized state outside the mold and is then forced into the closed mold for the curing step.

A double ram press having a pressure cylinder or well located directly above the top of the mold can be employed for transfer molding. The compound is loaded into the well and is heated to the flowing point but not the curing point. The lower ram moves the cavity of the mold upward to close the mold, after which the top ram moves downward to force the molten compound through sprues or runners into the mold. Curing is then accomplished in the usual manner.

Transfer molding has certain advantages over regular compression molding for some applications. For example, it is frequently used for molding products with inserts or undercuts. In regular compression molding, considerable stress is developed within the mold when the solid material liquifies, and frequently the inserts become dislodged or misaligned. No such stresses occur with transfer molding. Because of the uniform flow of material in transfer molding, it is commonly used to make products of complicated design.

INJECTION MOLDING

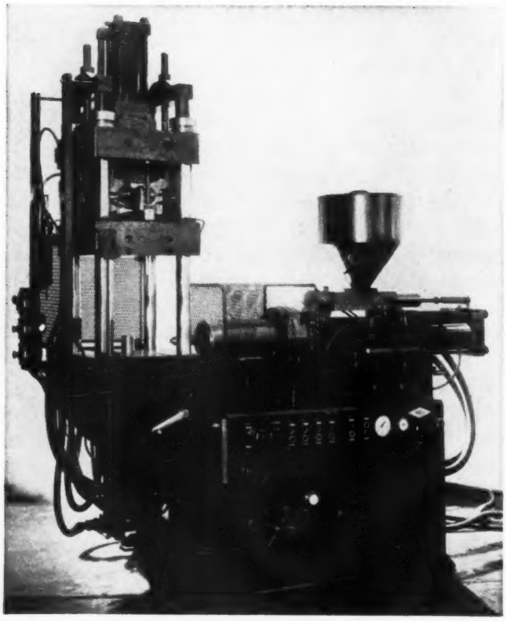


Courtesy of the Hydraulic Press Mfg. Company

Figure 5

Injection molding is used mainly for the thermoplastic materials and in principle is very similar to transfer molding. Granulated molding compound is fed from a hopper to an injection cylinder where it is liquified. A plunger then forces the liquid compound through a nozzle and into a closed mold. Unlike compression and transfer

* Saybolt Universal Second.



Courtesy of Improved Machinery Inc.

Figure 6 — 4 to 6 oz. Vertical Injection Molding Machine.

molding where the molds are heated to effect rigidity, injection molding requires that the mold be cooled to solidify the plastic.

Either electricity or steam is used to heat the plastic in the cylinder, and to increase the heating efficiency, each cylinder will usually contain a torpedo or spreader. The plunger which moves the compound through the cylinder is hydraulically operated.

The molds are mounted on faceplates and are opened and closed either hydraulically or mechanically. Water is used to cool the molds and reduce the temperature of the plastic to some level below its melting point.

Most of the injection molding machines have a horizontal heating cylinder and vertical faceplates for holding the mold. Thus when the mold is opened, the product readily drops out. Unlike the compression molding machines whose capacities are rated in the tons of force they can develop, the injection molding machines are rated according to the ounces of compound that can be injected into a mold per stroke of the plunger. Single nozzle machines can inject up to 32 ounces per stroke. Machines with more than one nozzle have much larger capacities.

Pre-plasticizing units are now available for use with injection molding machines. These units are located between the feed hopper and the injection cylinder and serve to transform the plastic from a solid to a liquid before it enters the latter. There are numerous advantages to be gained by the use of a Pre-Plasticizer, among which are increased injection capacity for a machine of a fixed rating, lower injection pressures, better temperature control and higher production rates.

Lubrication Requirements for Injection Molding Presses

The discussion of the hydraulic systems of compression presses applies equally well to those of the injection presses. Premium grade hydraulic oil of the viscosity recommended by the equipment manufacturer should be employed. In general, an oil having an SSU viscosity at 100°F. of 175-200 seconds is recommended for systems operating below 1,000 psi and one of 300 seconds for systems where the pressure exceeds 1,000 psi.

Injection machines which employ toggle mechanisms to operate the die heads have many bearings to be lubricated. Most of the newer machines have built-in automatic lubrication systems to insure that each bearing is lubricated in accordance with its own requirement. A typical automatic system will consist of a reservoir to hold the lubricant, a pump, tubing, and meter units to deliver a given quantity of lubricant. One meter unit will be located at or near each bearing and filter discs either in the meters or at the pump inlet will protect the bearings from dirt and the abrasive plastic powder. Sight glasses suitably placed on the reservoir permit the operator to easily check on the supply of lubricant. Due to the high pressure that develops, regular straight mineral machine oil is not satisfactory for lubricating the bearings. An SAE 90 EP oil of high film strength is recommended for this service. The additives in the oil must not separate or clog the filters. For grease lubricated bearings, a No. 1 grade EP grease is suggested.

Certain points such as the link mechanisms, gear boxes and pump couplings may not be reached by the automatic lubrication system and will require special attention. The same EP oil used for the bearings will be satisfactory for these requirements.

The pump and motor bearings should be lubricated once or twice a year with a No. 2 grade mixed base high temperature pressure gun grease.

EXTRUSION

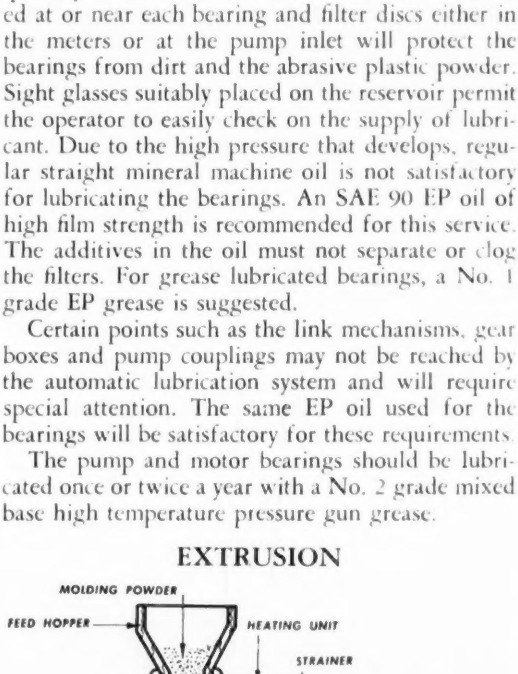
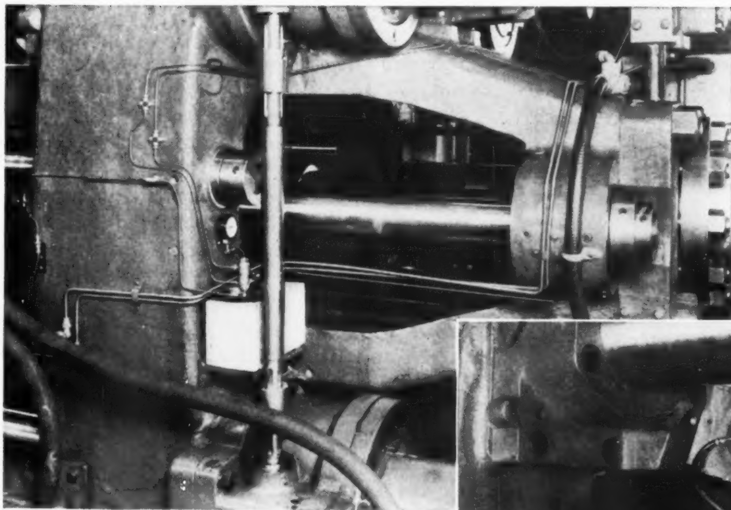
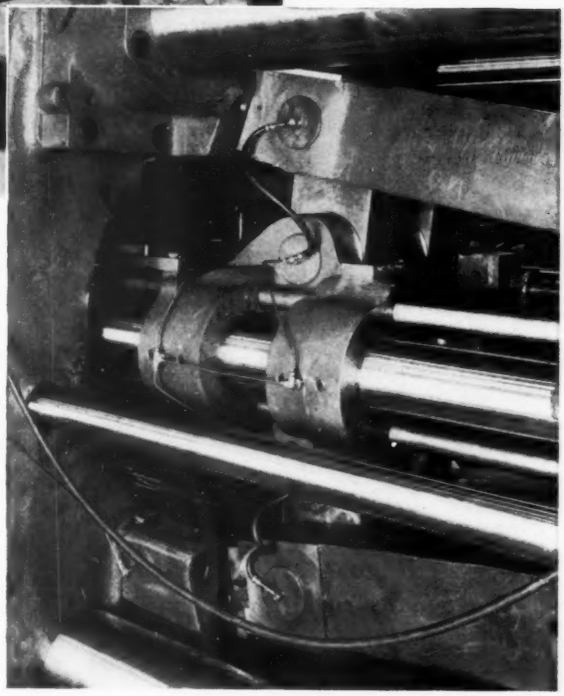


Figure 7 *Courtesy of the Society of Plastics Industry, Inc.*

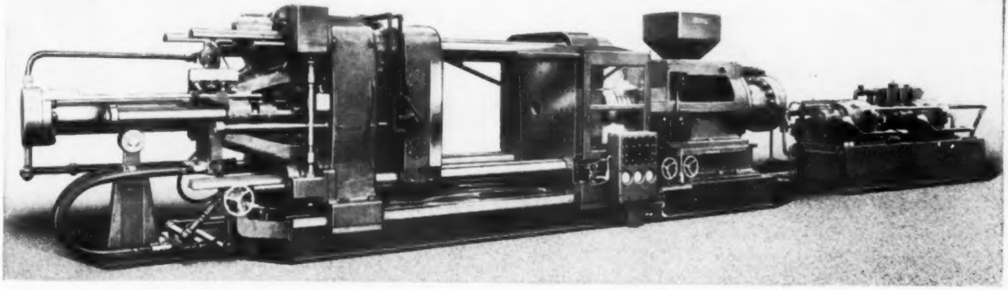


Rear Automatic Lubricating Unit from 200 oz. Injection Machine.



Close-up of Automatic Lubricating System for Link Mechanism on 200 oz. Injection Machine.

Courtesy of Reed-Prentice Corp.



200 oz. Injection Molding Machine with Separate Hydraulic Pump and Motor Unit.

Figure 8

Courtesy of F. J. Stokes Machine Co.
Figure 9 — Plastic Extrusion Machine.

This is a continuous process for converting thermoplastic materials into sheets, film, rods, tubes or filaments. Compared to the molding machines, the extrusion equipment is relatively simple. Dry plastic powder contained in a hopper is fed into one end of a cylinder. If the powder is not perfectly dry, the extruded product may contain bubbles or blisters. The cylinder is heated and the powder is moved along by means of a continuously rotating screw. A "torpedo" mixing device is also sometimes used in conjunction with screw delivery. It provides a thin film of plastic for final uniform heating and it reduces fluctuations in delivery by the screw. At the other end of the cylinder the plasticized powder is forced through a die and onto a canvas or rubber conveyor belt. The main problem in the extrusion process arises as the material leaves the die, since at this point it is hot and soft and can be deformed easily. Hardening of the plastic is accomplished either by cooling with air or by immersion in water.

Both single and multiple cavity dies can be employed, and they, like the molds, may be chrome plated to reduce corrosion and wear.

The temperatures used in the extruder will vary with the particular machine, the shape being extruded, and the type of plastic material being processed. Temperatures may range from 250°F. to 650°F. and they must be very carefully controlled to provide the proper fluidity and the desired finish. Too low temperatures usually give a dull matte finish, while too high temperatures will give a rough finish caused by material sticking to the die.

Rigid plastics for extrusion usually consist of high molecular weight resins. They also contain heat stabilizer, to protect from thermal decomposition during processing; lubricant, to eliminate sticking in the processing equipment; pigment, to provide color; and possibly filler to improve gloss or smoothness.

Rigid extrusions are used for making corrosion resistant pipe, insulating tubes, rigid sheets for fume hoods, ducts and tank linings, hot water stand pipes, pipe liners, structural shapes, refrigerator breaker strips, plastic welding rods, table and shelf edging, knitting needles, lighting louvres and a multitude of other applications.

Flexible plastics used for extrusion consist of resin, stabilizer, lubricant, pigment, possibly filler, and in addition a plasticizer which imparts rubbery or flexible properties. Flexible extrusions include film, sheeting, hoses and tubes, tape, wire insulation and many other applications.

Lubrication Requirements for Extrusion Machines

Heavy pressure is necessary for forcing plastic material through the die. Consequently the gears and bearings, especially the thrust bearing, are heavily loaded. The use of the proper type of lubricant will minimize wear on the parts and will promote smooth operation of the equipment.

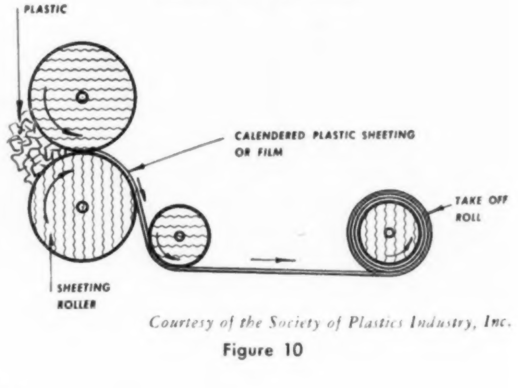
The following types of lubricants are usually specified for various parts of the extruder:

For the Main Screw Radial and Thrust Bearings, Enclosed Drive Gears and Bearings (Lubricated by Splash or Circulating System), Feed Roller Gears and Bearings (Bath Lubricated), a Mild Type EP Lubricant of 110 to 165 SSU Viscosity at 210° F. should be employed. High grade heavy bodied steam Cylinder Type Oils of similar viscosity can also be used.

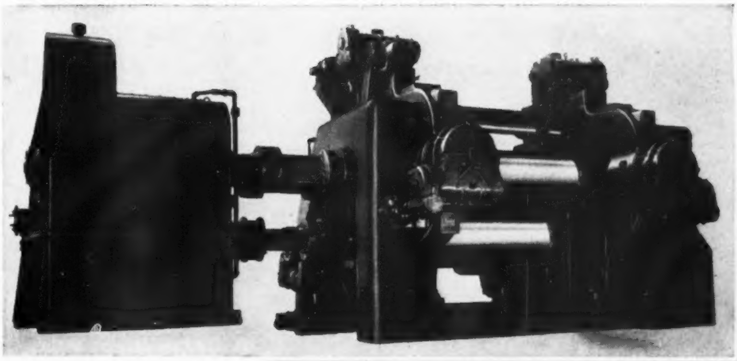
Motor Sleeve Bearings require a high grade oil of 275 to 325 SSU Viscosity at 100°F.

All anti-friction bearings can be lubricated with a heavy duty grease of No. 2 NLGI grade.

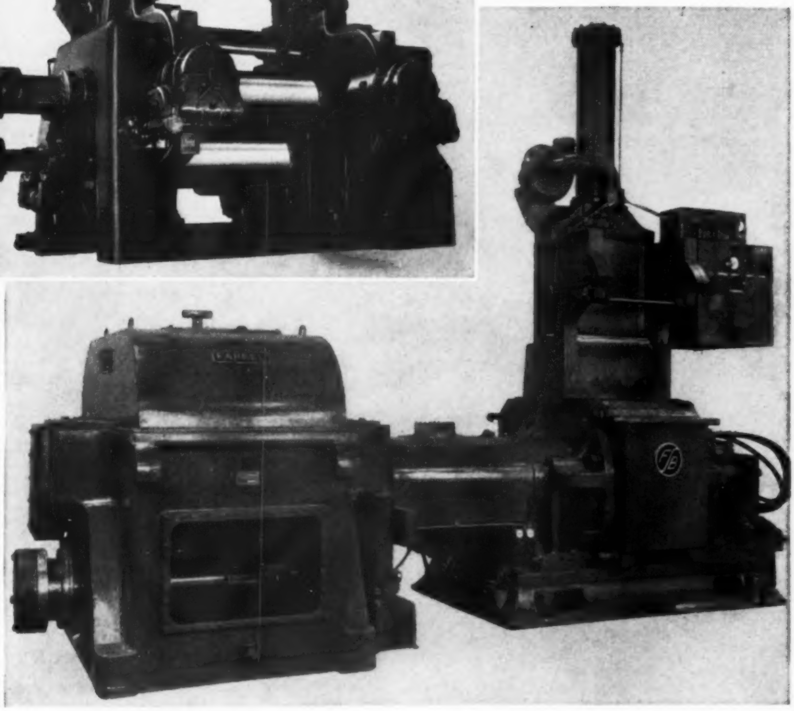
CALENDERING



Courtesy of the Society of Plastics Industry, Inc.
Figure 10

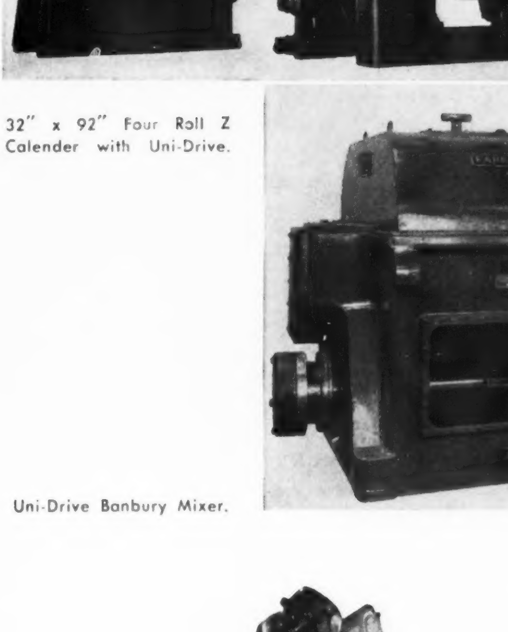


32" x 92" Four Roll Z Calender with Uni-Drive.



Uni-Drive Banbury Mixer.

Figure 11 *Courtesy of Farrel-Birmingham Co.*



Courtesy of Adamson United Co.

Figure 12 — 32" x 92" Four Roll Inverted L Calender.

Calendering is used to convert thermoplastic materials into continuous sheets and films and to apply a plastic coating to textiles. Although there are many varieties of calenders available, those used for plastics processing are either of the 4-roll inverted L type or the 4-roll Z type.

In the calendering operation a bank of hot plastic compound is fed in the nip between the first and second rolls. The plastic emerges from these two rolls as a sheet which is then fed between the second and third rolls and subsequently between the third and fourth rolls. The finished sheet coming from the calender is passed over and around four or five cooling rolls and then proceeds to a festooner and windup equipment.

In a coating operation the material to be coated is introduced between the second and third rolls along with the plastic sheet from the first two rolls. The material coming from the calender will have a plastic coating on one side. If both sides are to be coated, the sheet will have to be passed through the calender again.

Calender rolls are usually made of chilled iron and the surface may be smooth or matted. The thickness of the finished sheet is determined by the

space between the rollers, and the thickness of a given sheet must be accurate to within 0.0001 inches. Some of the newer calenders are equipped with rolls as large as 36x96 inches and can produce up to 158 yards of sheeting per minute. The rolls are usually steam heated to maintain the plasticity of the material and are driven by an electric motor, with power transmitted through gear stands connected to the rolls by universal spindles.

Lubrication Requirements for Calenders

Some of the calender rolls are equipped with precision roller bearings while others have the plain sleeve type bronze bearings. Considerable pressure is exerted on the bearings and they are usually water-cooled to prevent them from becoming so hot as to cause softening of the bearing metal. Older types of calender bearings are lubricated by compression grease cups, grease pockets in the top bearing caps or by heavy oil. Modern calenders provide for automatic lubrication of the bearings through either a mechanical force feed lubricator or flood lubrication of the journal boxes with a circulating pump, oil cooler, filter and reservoir.

The viscosity of the oil required for calender bearings depends upon the journal temperature. Up to 140°F. an oil of 75-125 seconds SSU Viscosity at 210°F. is suggested. Above this temperature heavier oils with maximum viscosity of 330 seconds at 210°F. are required. For grease lubricated bearings, a heavy duty grease that has been compounded with a fairly high viscosity mineral oil is acceptable.

Banbury Mixer

In the calendering of plastics, the hot compound fed to the calender rolls is prepared in an internal mixing machine such as a Banbury Mixer. In this machine the ingredients are intimately blended into a homogeneous pliable mass.

The Banbury Mixer has exceptionally rugged construction because of the heavy duty work it must perform. The machine consists essentially of an enclosed trough or mixing chamber in which operate two mixing rotors or blades, a hopper into which the materials are fed, and a sliding door in the bottom through which the mixed batch is discharged. The blades of the rotors are formed in an interrupted spiral and the rotors are operated at slightly different speeds to apply a smearing action between the component particles. Water sprays are installed around the body of the machine for cooling. The rotors also have cooling elements. End thrust adjustments are provided to absorb the slight axial forces developed by the spiral blades and to prevent stock from working out through the housings. These adjustments are designed for close fitting and follow-up as wear occurs.

A two-speed motor is optional so that the machine can be operated not only at standard speed but at a somewhat higher speed where desirable. The temperature of working is controlled by the amount of cooling water which is circulated through the cored rotors and sprayed against the side walls.

Some of the older mixers were designed for a top horsepower of 250 at 20 R.P.M. but the newer machines develop horsepower of 800 at 40 R.P.M. The latter are capable of handling heavier loads resulting from mixing tougher stocks at higher speeds. The new machines now have 3 distinct parts as follows:

1 — Gears which were formerly mounted on the rotors are now enclosed, with the primary reduction gears in a separate housing. Gears and bearings are lubricated automatically. Mild EP Gear Lubricants (leaded type) are usually used.

2 — Universal spindles connect the drive with the Banbury rotors and power is transmitted to each individually. These are lubricated with adhesive type greases of Grades 1 or 2.

3 — The Banbury Mixer itself has been strengthened and new, harder materials are used for the working elements to withstand the more intensive work of mixing the stiffer stocks coming into use. The main bearings, thrust collars and discharge door rails are lubricated with a heavy duty type EP Grease of No. 1 Grade by means of a force feed grease system.

CONCLUSIONS

The plastics industry is probably the fastest growing industry in the country. The production of plastics has increased over five fold during the past ten years. In the processing of plastics, whereby the raw powder is transformed into molded products, sheets, tubes, or rods, equipment such as hydraulic presses, extruders, calenders and internal mixers are employed. In order to maintain production quotas, it is essential that these machines operate continuously with as little downtime as possible. Continuous operation depends upon satisfactory lubrication, and the petroleum industry is proud of the role it plays in keeping the production of plastics on schedule.

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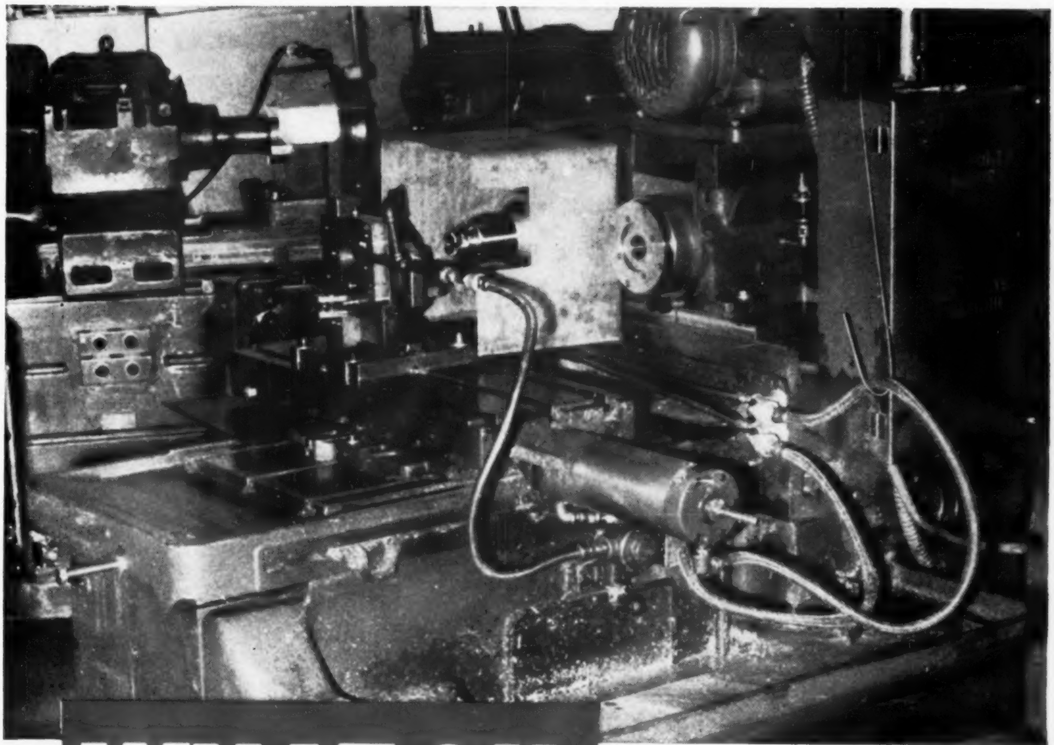

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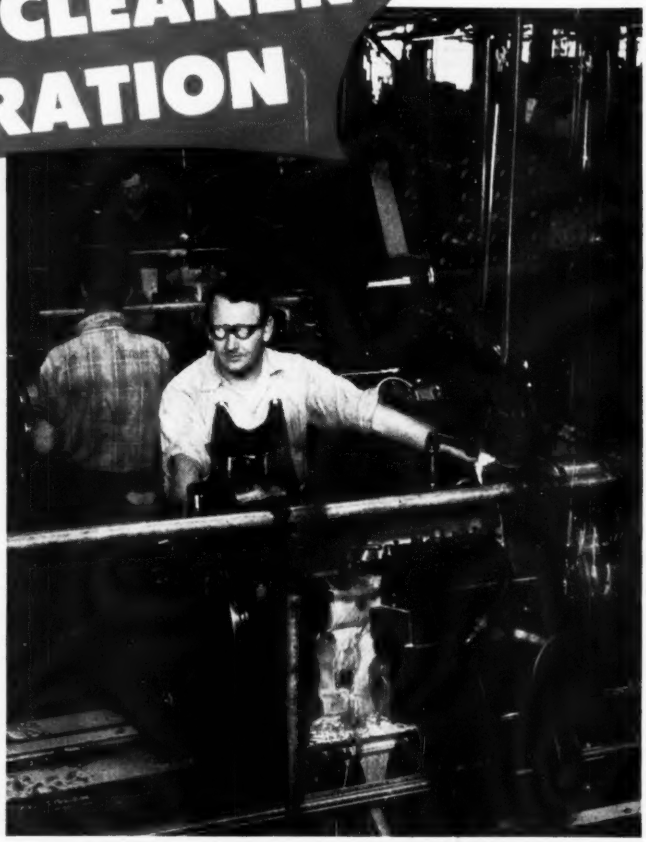

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